POLICY INCENTIVES FOR INDUSTRIAL ENERGY CONSERVATION

Anandalingam G.

Discussion Paper No.02.83

Tata Energy Research Institute
7, Jor Bagh.
New Delhi

1983

This work was partly funded by a Fellowship from the Rockfeller Foundation. Comments from R.K.Pachauri, V.Raghuraman, R.Bhatia and R.Jayshankar are acknowledged.

Contents

1. Introduction

There have been various studies on the energy intensity and conservation potential in the industralised countries. These studies have revealed conclusively that, from economic and technological viewpoints, there are substantial opportunities for using energy more efficiently in all sectors of the national economy. One representative study has indicated that an average of 25% of energy use in the U.S. manufacturing sector could be saved through measures whose capital and life-cycle costs are less than those needed to generate equivalent amounts of energy supply (Uri, N.D., 1979). According to the study these levels of savings would necessiate significant changes in government policy.

Similar studies on India are few; studies on conservation technologies in individual industries and fragmented studies on estimating energy intensities are available.

Table 1 : Energy Intensities in Selected Industries (in G.Cal/Tonne)

	Steel	Cement	Aluminium	Pulp & Paper	Fertilizer	Textiles
India	9.50	2.00	33.00	11.13	11.25	22.40
Italy	4.03	0.89	-	-	9.92	-
Japan	4.18	1.20	13.90	-	-	-
Sweden	5.02	1.40	16.50	7.56	-	-
U.K.	6.07	1.30	21.10	7.62	11.23	-
U.S.A.	6.06	0.95	9.50	9.70	11.32	12.10
West Germany	5.21	0.82	14.90	-	-	-
India Over Lowest	57.6%	59.0%	71.2%	32.1%	11.8%	46.0
India Over Highest	36.1%	30.0%	36.1%	12.8%	-8.7%	

Source: The figures are the authors estimates (1979-80) taken from the most reliable of recent sources.

From the present evidence (Table 1) it is clear that (i) energy intensity, measured in kilo calories per unit of production, is higher in most Indian industries than in other countries and (ii) there is considerable scope for energy conservation. In addition, it is clear that most energy consumption investments are extremely cost-effective with pay-back periods ranging from a few months to less than three years (Ravi Shankar, K., and Pachauri, R.K., 1982).

There are various reasons for high energy intensity in Indian industries. First, most industries have little incentive to improve energy efficiency because energy costs form a small portion of production costs (Table 2).

Table 2 : Energy Costs in Indian Industry 1978-79

Industry	Energy costs/manufacturing costs (per cent)
Aluminium	27.30
Cement	23.13
Glasss	11.15
Paper	12.81
Foundaries	11.29
Basic Chemicals	9.80
Refractories	9.34
Chemical Fertilizers	9.33
Cotton Textiles	5.99
Metal Products	3.72

Source: B.Bowonder (1982).

Fuels have been subsidized to all sectors of the economy including industry with the intention of encouraging economic growth and this adds to the distinctive problem. For instance, the average electricity price (revenue per Kwh) charged to industry in 1976 was 18.8

paise/kwh compared to 29.0 paise/kwh for domestic and 21.9 paise/kwh for agriculture (Ministry of Energy, Government of India, 1980). At subsidized prices, the State Electricity Boards made a loss of Rs. 158 crores in 1977-78 (Ministry of Energy, Government of India, 1980). Similarly, coal price to industry does not take into account the full production and transportation costs. It has also been shown that the sale price of individual petroleum products are lower than their posted prices (Bhatia R., 1983). For petroleum products that are consumed in industry, naptha, furnace oil and high speed diesel, the ranges for the ratio of sale price to posted price were 68% to 115%, 69% to 103% and 87% to 97% respectively (Bhatia R., 1983).

Secondly, in the energy intensive industries such as steel, cement aluminium and petroleum refining, there are very few companies (Table 3).

Table 3 : Concentration Profile of Indian Industry, 1980

Industry	Number of Companies*	Production of Top 5 Units** (per cent)	Share of Public Sector** (per cent)
Steel***	2	100.0	83.2
Cement	23	64.4	16.5
Aluminium	5	100.0	15.0
Fertilizer	9	90.3	70.7
Petroleum Refining	4	100.0	98.5

Source: Author's estimates from the most reliable of recent sources.

Note: * "Public Sector" is considered to be one company and includes state owned enterprises.

** Where production data is not available, capacity data has been used.

*** Only includes integrated steel plants.

Being oligopolies, increased energy costs are easily passed on to consumers. In cases where there are administered prices for products, there should be some incentive for reducing energy costs. However, many of the industries where administered prices operate are also in the public sector (Table 3) where increasing profits do not necessarily form the modus operandi. There is little incentive to cut production costs under these conditions.

Thirdly, major conservation efforts require process modification and technological investment. These demand capital that is usually scarce. In the Indian context where there is growing demand for industrial goods, most industries prefer to invest capital in capacity expansion at the lowest per unit cost. Often this means the installation of obscure but cheap machines and production systems, albeit at a great energy inefficiency.

Finally, with varying problems that face industries, shortage of inputs, labour unrest, maintenance and marketing problems, scarce management capabilities are seldom directed at energy conservation.

Thus energy conservation would be followed in Indian industry only if there are considerable, government directed incentives. These incentives fall under the following categories (i) those that relate to the structure of energy prices in the economy, (ii) those that deal with financial parameters and (iii) those that deal with direct government regulations. This paper analyses these policy incentives for industrial energy conservation in India, suggests some criteria for evaluating the policies and discusses some problems with providing investment incentives.

2. Pricing Policy

2.1 Prices

Most developing countries subsidize energy prices, especially the price of fuels such as kerosene which is used by the poorest section of the population. Subsidizing fuel prices for industrial users, however, would be a powerful disincentive for energy conservation. Energy prices that affect industry should be allowed to reach their market prices. Economic theory suggests that appropriate energy prices should ideally reflect all external costs associated with energy

production and use, including premiums for environmental damage, risk, and security of supply. Thus, non-renewable energy sources such as coal should be priced at replacement costs[6] (i.e. the current cost of new supplies) rather than at "rolled in" or average prices. Increasing the price of commercial energy due to considerations such as these would increase the incentive for conservation by making fuels more costly. Thus the price that industry pays for energy sources should be at the appropriate free market prices.

Various Government of India committees have recommended that commercial fuels should be priced at their Long Run Marginal Costs, LMRC (i.e. cost of replacement). The recent coal pricing study by the Bureau of Industrial Costs and Prices (BICP) has recommended that a "scarcity rent" should be added to the cost of production of coal (The Economic Times (1983). However, the BICP study cautions that "for a vital commodity like coal, higher prices can lead to substantial increase in the general price level". In industries where administered prices prevail, this argument does not hold. In addition, if high energy costs induce increase in energy efficiency and industrial productivity, the net result would only lead to an insignificant increase in the price level. What is true though is that the price of fuels in India, especially electricity, are much lower than their replacement costs.

Table 4 shows the results of a study on estimating marginal cost based electricity tariffs in India (M.W. Gellerson (1978).

Table 4 : Comparison of Marginal Cost and Tariffs in Power Sector in India, 1976 - 1977

Region	Average Tariff* (paise / Kwh)		Ratio of Marginal Cost to Average Cost	
	Small Indus-/try	Large Indus-try	Small Indus-/try	Large Indus-try
North	22.09	22.27	4.46	1.29
South	24.49	20.45	4.33	1.86
East	24.00	21.87	2.67	1.20
West	25.03	22.15	2.69	1.14

Source: M.W. Gellerson (1978).
Note : *Average Revenues realised from sale of

electricity by State Electricity Board.
It should be emphasised that these costs are <u>present</u> marginal costs and not replacement or long-run marginal costs. The latter costs would be higher. Even so, there is considerable difference between the marginal costs and tariffs. The difference depends on the type of consumer; tariffs charged to large industries are closer to the marginal cost of providing them with electricity than in the case of small industries. It has been shown that the marginal cost of providing agricultural consumers with electricity far outweighs the revenue per kilowatt-hour received from them (M.W.Gellerson, 1978).

2.2 <u>Tariffs and Taxes</u>

Even when energy is at the international market price, it would not reflect the costs to the nation of balance of payments problems, massive energy imports or the environmental costs of energy use. These effects make the total social cost of energy even higher than the cost that would result if regulatory and subsidy distortions were removed completely.

Another government policy option, therefore, is to set <u>tariffs</u> for imported oil or taxes for energy use. The advantages of both tariffs and energy use taxes is that they affect the economy or the industrial sector as a whole and do not involve the government in detailed planning. Moreover, the actual level of the tariffs and taxes can only be set after economic analysis. Energy use taxes have received increasing attention in the U.S. in recent years (Hatsopoulos, G.N., Gyftopoulos, E.P., Sant, R.W. and Widmer, T.F., 1978, Brown S.P.A. and Anandalingam, G., 1981) with the general consensus that they should be a very strong instrument of government policy. A recent analysis of net-energy use comes out in favour of tariffs over investment subsidies for encouraging energy efficiency in industry (Baumol, W.J. and Wolf, E.N. (1981).

However, one major difficulty with increasing the price of energy or setting energy taxes or tariffs is that many energy intensive industries in developing countries are already facing severe financial difficulties. Many marginal energy intensive firms, rather than conserving energy, would cease operations. Any program that is designed to improve energy efficiency by increasing the cost of energy use might have to be accompanied by measures that can provide these industries with the capital they will need to make energy conserving investments.

2.3 Impact of Increase in Prices

An increase in the price of energy would essentially lead to a reduction in demand. The actual change in the consumption would depend on the price-elasticity of demand. In addition, increasing the price of one fuel (say, oil) would lead to a substitution of another fuel (say, coal) for the same use. For the pricing policy to succeed the knowledge of short and long run response of industrial energy demand to price changes would be essential.

Studies on price elasticity of demand for oil in developing countries have been attempted at various stages. Results of a recent study are shown in Table 5.

Table 5 : Oil Price Elasticity Estimates for Selected Countries

Country	Price Elasticity	
	Short Run	Long Run
Bolivia	-0.03	-0.03
Iran	-0.43	-0.43
Mexico	-0.08	-0.15
Paraguay	-0.01	-0.04
Thailand	-0.13	-0.28

Source : Lee J., Mubayi V, and Anandalingam, G. (1983).

Price elasticities for the other fuels are much more difficult to estimate. Elasticity prices are subsidised and show insufficient variation for any reasonable econometric analysis. In India, there is a great excess of demand over supply, and industry consumes all the electricity that is supplied at even high prices. The price elasticity of electricity consumption may not mean much in the Indian context. The cost of alternative supply of electricity, i.e. captive power, is quite large. Coal and natural gas have markets only in a few countries and there too the data are fragmented at best.

It is clear that the oil demand in developing countries is quite elastic in the long run, contrary to the

initial expectation from the experience of developed countries. In the short run, oil demand is much less elastic reflecting slow adjustment to energy prices which is to be expected in developing countries. There is a lag between the increase in energy prices and the investment in equipment that leads to a reduction in specific energy consumption. This is most applicable to the industrial sector in India. Adjustment to price changes is not significant in the transportation sector (see Table 6).

Table 6 : Estimates of Price Elasticities of Fuel Demand in India

Sector	η_{cc}	η_{oo}	η_{ee}	η_{co}	η_{ce}	η_{oc}	η_{oe}	η_{ec}	η_{eo}
Manufacturing	-0.15	-0.09	-0.14	0.13	0.16	0.15	0.12	0.10	0.09
Transportation	-0.32	-0.10	-	0.06	-	0.23	-	-	-
Residential	-0.18	-0.14	-0.22	0.09	0.19	0.23	0.20	0.14	0.02
Agricultural	-	-0.03	-0.20	-	-	-	0.09	-	0.02
Commercial	-0.16	-0.03	-0.03	0.01	0.01	0.08	0.22	0.04	0.01
Total	-0.20	-0.10	-0.21	0.11	0.11	0.24	0.13	0.09	0.04

Source N.D. Uri (1979)
Note c = coal
o = oil
e = electricity
- = quantity of fuel used less than 2 per cent.

Energy demand has also been modelled as a <u>derived</u> factor demand using a cost function containing prices and quantities of capital, labour, energy and other materials. The other used model in such studies is the Trans-logarithmic Cost Function (Christensen, L.R., Jorgenson, D.W., and Lan, L.J., 1971). Uri has used the translog cost function approach to estimate energy demand for the commercial sector, coal, oil and elasticity in India (Uri, N.D., 1979). The results of his work (Table 6) show a wide variation in sectoral price elasticities of demand. The industrial sector,

surprisingly, has the most inelastic demand for coal and electricity. It appears that the overall possibility for substitution between all fuels is quite significant. Higher oil prices will create a stimulus to coal use in industry, the stimulus to substitution of electricity for oil will be less. One needs to add a caveat to the estimated elasticities. Of the oil used in industry, that portion that relates to captive generation, mostly diesel, may not allow for much substitution. Coal based captive power plants require lumpy large investment that may not be available to industry. In any case, captive power plants need to be switched on with some rapidity, and oil based systems are much more useful for this purpose.

A more recent study by Ravi Shankar and Pachauri (Ravi Shankar, K., and Pachauri, R.K., 1982) also using the translog model, estimates the price elasticity of energy demand in selected industrial sectors (Table 7.).

Table 7 : Estimates of Price Elasticities in Selected Indian Industries

Sector	n_{cc}	n_{oo}	n_{ec}	n_{co}	n_{ce}	n_{oc}	n_{oe}	n_{ec}	n_{eo}
Sugar	-0.07	-0.08	-0.12	0.23	0.95	0.29	0.51	0.39	0.16
Cotton Textiles	-0.12	-0.63	-0.10	0.02	-0.25	0.16	-0.64	0.09	-0.02
Paper	-1.04	-0.16	-0.25	0.17	0.06	-1.63	0.37	0.70	0.04
Fertilizers*	-0.02	-0.63	-0.05	-0.02	0.21	-0.09	-0.78	0.06	-0.09
Chemicals*	-0.40	-0.01	-0.06	0.02	0.44	0.18	-0.42	0.07	-0.01
Refinery	0.72	-0.93	-0.01	-0.32	4.92	-0.001	0.09	0.000	0.17
Cement	-0.02	-0.27	-0.08	0.004	0.02	0.15	-0.04	0.04	-0.001
Iron & Steel	-1.50	-0.10	-0.62	-0.12	-1.35	-0.60	0.42	-0.57	0.04
Non-Ferrous Metals	-0.55	-0.15	-0.10	0.10	0.42	0.36	-0.03	0.09	-0.002

Source: Ravi Shankar and Pachauri (1982)
All estimates 1965-67, except for Refining 1970-74

Notes :
c = coal
o = petroleum products
e = electricity
* = inorganic

The increase in the price of oil will lead to much greater reduction in demand in industries such as cotton textiles, paper, fertilizers, refining and cement than in other sectors. The increase in the price of all of the fuels will have a significant impact on the energy intensive industries listed in Table 7. In most cases, significant fuel substitution takes place. For instance, increasing the price of imported oil would

lead to the substitution of domestic coal in most industries. The exception, refining and iron and steel, need to be examined more closely to come to any useful conclusions.

To summarise, empirical results of studies in India show that an increase in the price of commercial fuels, especially oil will lead to a reduction in demand, i.e. conservation or substitution of domestic fuels for imported oil. The effects are most pronounced in the energy intensive sectors where estimates of the price elasticity of energy demand are the greatest. As such, an appropriate pricing policy will provide a powerful incentive for industrial energy conservation in India.

3. Financial Incentives

Taxation policies and other financial measures can be very powerful incentives for investment in new equipment. There are various instruments available to the Government for creating a favourable financial environment for industrial energy conservation. These include; (i) direct cost sharing in the investment; (ii) allowing soft loans with low interest rates; (iii) reducing corporate income tax rates for participating firms, (iv) extending investment tax credits; (v) allowing rapid depreciation of conservation equipment. All of these measures reduce the cost of capital in one way or other.

3.1 Reducing Corporate Income Tax Rates

A programme that allows a reduction in the corporate income tax rate for companies that participate in energy conservation activities would provide a powerful incentive. The reduction of the corporate income tax rate would encourage capital formation in industry because a greater portion of the returns on this investment would be retained by the firm. Thus, the value of energy savings (ie, cost reductions) would be greater with a low corporate tax rate.

A possible weakness in this policy is that it applies to all income, whether derived from increased industrial or energy productivity or some other source (Eisner, R., and Lawler, P.J., 1975). In addition, companies would indulge in energy "conservation" activities that may not result in net energy gains or be economical. Such practices need to be carefully monitored to make effective the incentive of providing corporate income

tax reductions. Reducing corporate income tax rates for only effective conservation measures would require large informational, contractual and policing costs.

3.2 Investment Tax Credits

An alternative and more carefully focused program would be to provide tax credits for selected energy conservation investments. Firms would be allowed to take a certain percentage of their capital investment as credits on taxes owed to the government.

There are certain disadvantages of this policy. Industry would probably nominate for the tax credit all energy conservation investments rather than only these investments made economical by the presence of the tax credits (Brown, S.P.A. and Anandaalingam, G.). It would be very difficult for government makers to assess the economics of all investments on a firm-by-firm basis. Thus, the Treasury of the developing country is likely to lose tax revenue in excess of that anticipated. A further difficulty with tax credits is that many firms for which incentives are appropriate (i.e. the energy intensive firms) have little tax liability; for this reason a refundable tax credit policy should be considered.

3.3 Rapid Depreciation

Capital investment would be encouraged if industrial equipment could be written off early for taxation purposes. One way to do this would be to allow accelerated depreciation of capital. Accelerated depreciation could either be for all investments leading to increased industrial productivity or for a specific energy conservation investments. For capital with long equipment life, depreciation should be indexed to inflation or to the price of capital (interest rate).

There are various methods of accounting for accelerated depreciation. The simplest is the straight-line method, where capital is depreciated in equal portions over a specified depreciation life which is usually much shorter than the equipment life. Other methods of depreciating capital are the Sum-of-Year and Double-Declining Balance Depreciation (Anandalingam, G., Jhirad, D., Mubayi, V. and Weingart, J.). It is possible for the policy maker to specify the depreciation method that would lead to increased private investment while maintaining the lowest possible revenue losses to the treasury.

3.4 Financial Incentives in India

In the 1983-84 tax schedules, there are a number of provisions that could be used by industries investing in energy conservation (Singhania, V.K. and Singhania, J., 1983). One provision that has gained wide publicity is the 100% depreciation allowance for "energy saving devices" to be available in 1984-85. A 30% depreciation allowance is already in effect. In addition to that allowance, there are other measures not directed specifically at energy conservation. However, tax credits for "expenditure on scientific research" (section 35) and for "programmes of conservation of natural resources" (section 35 CCB) can also be easily interpreted to include energy conservation equipment (samples I and II).

Sample I

Tax Incentives for Energy Conservation in India- Depreciation

DEPRECIATION ALLOWANCE : 30% (1983-84); 100% (1984-85)

QUALIFIED EQUIPMENT:

1. Specialised Boilers and Furnaces
   - i) Inguifluid/Fluidized Bed Boilers
   - ii) Flameless Furnaces
   - iii) Fluidized Bed Type Heat Treatment Furnaces
   - iv) High Efficiency Boilerrs
     - Coal : greater than 75%
     - Oil/gas : greater than 80%

2. Instrumentation & Monitoring Systems for Monitoring Energy Flows
   - i) Automatic electric load monitoring systems
   - ii) Digital Heat Loss Meters
   - iii) Micro-processor based control systems

3. Waste Heat Recovery Equipment and Cogeneration Systems
   - i) Economisers and feed water heaters
   - ii) Recuperators and Air pre-heaters
   - iii) Back-pressure turbines for cogeneration
   - iv) Heat pumps
   - v) Vapour absorption refrigeration systems
   - vi) Organic rankine cycle power systems
   - vii) Low inlet pressure small steam turbines

4. Power Factor Connecting Devices
   - i) Shunt capacitors and synchronous condenser system

Sample* IX

Tax Incentives for Energy Conservation in India[16]
Deductions and Allowances

Section/Amount		Nature of Deduction
I.	32A (25% of Asset)	**INVESTMENT ALLOWANCE** Eligible: New Plant installed after March 31, 1976 for the purpose of generation or distribution of electricity or other form of power. Comment : Could be used for cogeneration.
II	35CCB	PAYMENT FOR CARRYING OUT PROGRAMMES OF CONSERVATION OF NATURAL RESOURCES Eligible: "Sums paid by a tax payer carrying on business or profession, to any association or institution, which has as its object the undertaking of programmes of conservation of natural resources, to be used for such programmes is allowed as a deduction in the computation of taxable profits[11]. Comments: Most waste heat recovery and material recycling investments can be claimed on this allowance.

Note: * This is just a sample and not complete; comments are the author's.

3.5 An Analysis of Financial Incentives

A number of technical and financial factors combine to determine the cost effectiveness of investment in energy conservation. A detailed analysis of the impact of the financial incentives on the Internal Rate of Return of the project was carried out for the substitution of solar energy for oil for producing industrial process heat in Zimbabwe (Anandalingam, G., Jhirad, D., Mubayi, V. and Weingart, J.). The main ingredients of the

financial model are shown in Table 8. Selected results are shown in figures 1 to 3.

Table 8 : Economic and Financial Parameters for the Base Case Solar Industrial Process Heat - Zimbabwe

Parameters	Value
Capital Cost	$ 2250/KW (th)
Percent Equity	50%
Debt Interest Rate	15%/year
Investment Life	20 years
Annual Savings (Cash flow)	$214 (based on $ 30/ bbl oil)
Cash Flow Escalation Rate	11% (Inflation + 3%)
Total O & M Costs	88%
O & M Escalation Rate	8% (Inflation)
% Capital Allowed for Depreciation	100%
Depreciation Life	7 years
Depreciation Method	Straight Line
Marginal Tax Rate	48%
Investment Tax Credit	25%

Source: Anandalingam et al

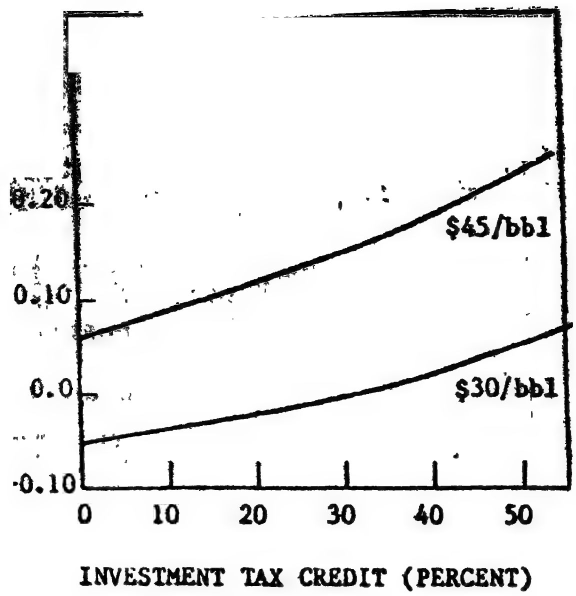


Figure .1 Internal Rate of Return (IRR) as a Function of Investment Tax Credit for the SIPH System.

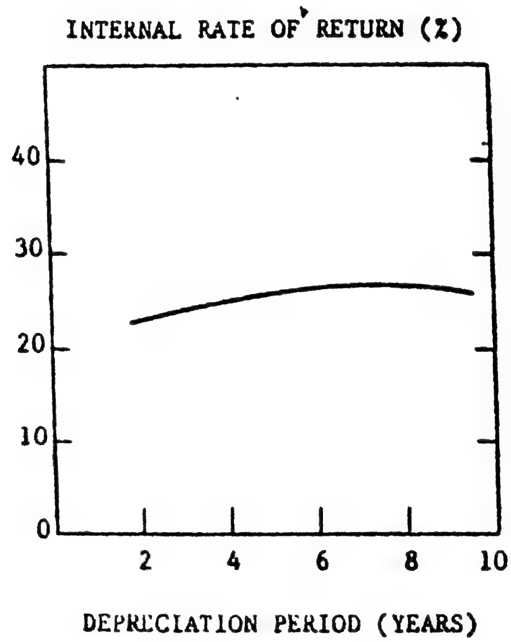
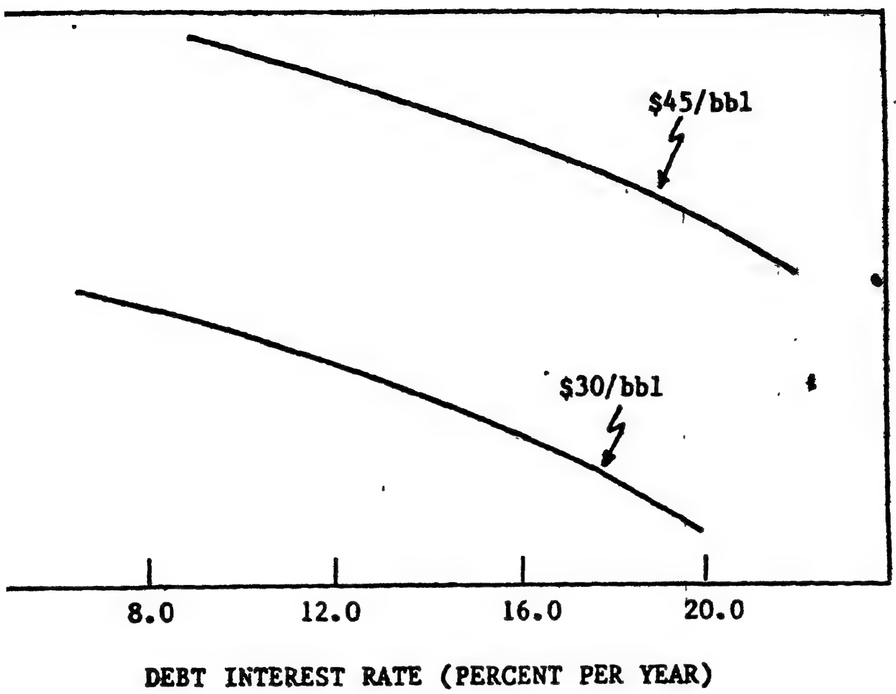


Figure .2 Internal Rate of Return as a Function of Straight Line Depreciation Period for Solar Industrial Process Heat.



3 Internal Rate of Return (IRR) as a Function of Debt Interest Rate, for the SIPH System.

is expected, providing soft loans (i.e. reducing the debt interest rate) and investment tax credits lead to an increase in the Internal Rate of Return or the cost effectiveness of the conservation project from the point of view of the Companys. It is clear that at an oil price of $ 30/bbl, the tax credit has to exceed 50% to be effective. Similarly a cost effective subsidized interest rate needs to be less than 4 percent. The depreciation period did not significantly affect the internal rate of return. In this particular case, rapid depreciation may not have increased the level of investment on the technology. It must be emphasised that the presented results are for <u>solar</u> energy use in industrial conservation. For the well established conservation equipment, the economics would be much more attractive.

A financial analysis such as the one carried out for Zimbabwe is essential before structuring the appropriate financial incentive. Such an analysis, while demonstrating that financial policy variables can play a powerful and decisive role in creating a favourable climate for investment in energy conservation, will also quantify the appropriate measures. Financial policies while providing incentives for investment by companies will also be costly to the economy in terms of government revenues foregone and other economic "distortion" effects. These are discussed in section 5.

4. <u>Direct Government Regulation</u>

Governments of developing countries can directly influence industrial energy conservation by (i) setting standards and targets for energy conservation; (ii) by providing technical assistance on means for improving energy efficiency; (iii) by controlling and rationing fuel and power allocation to encourage energy productivity; and (iv) by making institutional changes that would allow the free flow of electric power.

Many energy-intensive enterprises in the developing countries are government owned or government controlled public enterprises. This is particularly true of India. Public enterprises do not necessarily act to maximize profits or minimize costs. Often, changes in the price of energy and hence in the production cost would not encourage investment in energy productivity. The only way to achieve energy conservation is to set lighting, heating and air-conditioning standards and targets for such firms, and to make compulsory for all large industries to report annual energy use.

The United Kingdom, Department of Energy, after analyzing the energy conservation potential in individual industries, set energy savings targets to be met in five years (i.e. 1980). The targets ranged both from 15% to 25%, the latter relating to the pulp and paper industry. All the targets were exceeded by the industral sector in the U.K. (Anon, 1980). In India, ATIRA (Ahmedabad Textile Industry Research Association) has estimated the efficiencies that can be achieved in energy use in the textile industry and has publilshed norms or targets (Ahmedabad Textile Industry's Research Association, 1982).

Most western countries have public information programmes providing information on energy-saving techniques. Energy-audit schemes exist in several OECD countries and may be useful models in the developing countries. The U.K. Department of Energy provides an Energy Survey Scheme and recommends a list of recognised consultants who are knowledgeable in the field. The benefits of the scheme have been wide ranging (Anon, 1980). In the U.S., the National Bureau of Standards and the Department of Energy have published a series of energy management handbooks to assist businesses in developing and maintaining energy conservation programmes. This kind of assistance should be provided by the Indian government.

Governments can also ration energy or establish allocation schemes to promote energy conservation. Such schemes would be successful especially for imported fuels such as oil. Allocation schemes can complement rational pricing policies. Indeed, in most centrally planned countries like the Soviet Union, allocation schemes provide the major "market" signal to the manufacturing enterprises. Such schemes often require both detailed assessments and increased levels of bureaucracy. However, in cases where increasing the prices of fuels would cause inequities between different enterprises, allocation schemes could be the most rational.

Finally, government policy should include the dismantling of institutional barriers to energy conservation measures by allowing industry and utility interaction. The most important energy efficient technology that requires utility back-up is cogeneration, i.e., the combined generation of heat and power using the same energy source. The experience in the U.S. is quite revealing. Industries that cogenerate process steam and electricity are not able to meet their peak electricity requirements by on-site generation.

Conversely, during low demand periods, the industries would need customers for their excess electricity. The obvious partner to provide back-up electricity during low demand is the electric utility of the region. Until recently, utilities in the U.S., either refused to provide back-up electricity or charged exorbitant rates. The Public Utilities Regulatory Act (PURPA) provides guidelines for utility-industry interactions and set methods for establishing back-up and buy-back electricity rates (Brown, S.P.A. and Anandalingam, G., 1981).

In India the electric utilities, and the energy intensive industries are owned or controlled by the Central or State governments. Hence, it may be easier to make the necessary institutional changes that would allow for utility-industry inter-connections. Indeed such action is essential in promoting cogeneration and thus improving the total energy efficiency of Indian industry. In India, the State Electricity Boards usually discourage cogenerators (and even captive power producers) by not allowing parallel feeding with the electricity grid. In addition, there are "self generation taxes" in many States. These range from Rs. 0.13/Kwh in Orissa to Rs. 0.02/kwh in Delhi*. These would discourage cogeneration.

5. Policy Incentives and Public Costs

As with tariffs on oil prices, financial incentives distort the market because they bring into operation energy conservation measures that are not currently economical. The appropriateness of government policy would depend on the benefits and costs of such policies. There are two types of distortions. One relates to the misallocation of resources and the other to revenue losses to the government.

---

* private communication from V.Raghuraman, National Productivity Council.

5.1 Market Distortions

In Figure 4 we illustrate distortions caused by resource misallocation by a brief look at the extension of investment tax credits for industrial energy conservation. Supply and demand for energy conservation technology, in the absence of a investment tax credit, are illustrated by S_1 and D respectively. Supply is typically estimated through the use of engineering-cost data, statistical methods and economic theory. Demand indicates the "market" demand for the equipment. In the absence of the tax credits, the equilibrium price and quantity area P_1 and Q_1 respectively.

The existence of a business energy investment tax credits means that production of every quantity along S_1 can be profitable at a lower price, because the government "picks up" part of the cost. The resultant supply is represented by S_2, where the difference between S_1 and S_2 is the subsidy per unit of equipment. The new quantity is Q_2 which has the equilibrium price P_2.

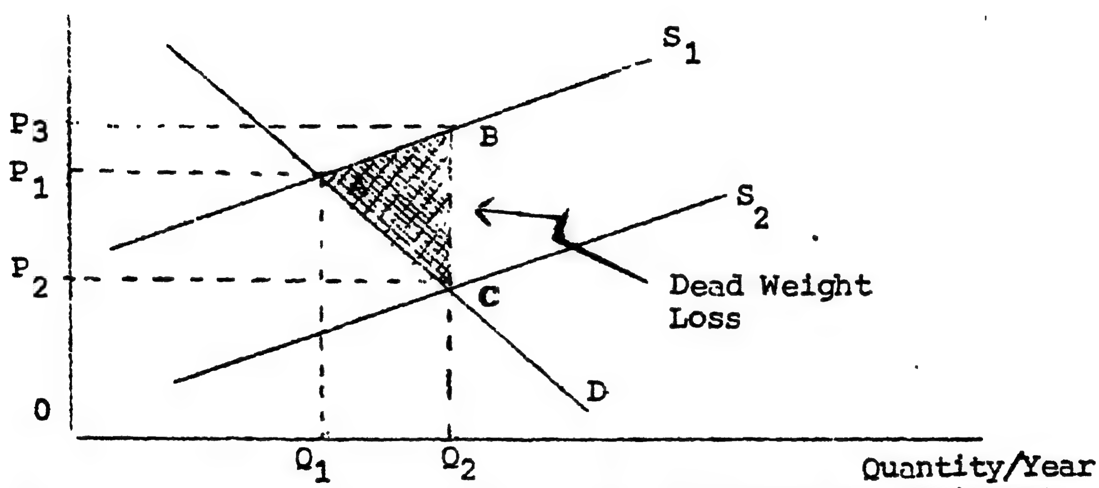


Figure 4: Supply & demand of energy conservation equipment.

The total "revenue" to production is represented by the rectangular area OP_3BQ_2, while OP_2CQ_2 is the total "revenue" from use. The difference, P_2P_3BC, is the direct revenue loss to the government treasury. The <u>true</u> marginal private cost of production is represented along S_1, while the private marginal value of use is represented along D. Thus, in increasing production from Q_1 to Q_2, we cause marginal cost to exceed marginal value, the result is a "dead weight loss*" represented by the triangle ABC. The difference between Q_1 to Q_2 directly or indirectly reflects the energy or oil savings. From a macro-economic perspective, the distortion costs created by Government policy should be estimated in order to analyse the social costs and benefits of energy efficiency investments. For instance, the distortion costs (area of triangle ABC) divided by the energy savings would give an estimate of additional benefit required from the energy conservation investment to overcome social costs. These additional benefits are usually the "premium" on energy savings, i.e., the difference between the shadow and market prices at which energy savings are estimated. If the required external benefits are less than the difference between the "shadow price" of oil used in project evaluation and the market price, the incentive scheme would be considered as being economically viable.

5.2 An Analysis of Market Distortions & Revenue Loss

In the U.S., the 1978 Tax Act provided investment tax credits for businesses investing in new energy source development and the substitution of other fuels for oil and gas. Qualifying investments for energy conservation included waste heat recovery equipments, non oil or gas combusters (principally coal boilers). Cogeneration equipment and solid waste recycling equipment. For each technology the impact of the credit on time paths of investment and energy saved, net economic ("distortions") cost of the credit to the U.S.Treasury and the appropriate shadow price (energy use premium plus market price of oil) were estimated (Brown, S.P.A. and Anandalingam, G., 1981) (Table 9).

---

*The "dead weight" loss is an important concept and crucial to any economic analysis of market distortions due to policy incentives. The uninitiated reader is referred to Henderson and Quandt[19].

Table 9 : Public Costs of Invesxtment Tax Credits (USA Example*)

Conservation Measures	Total Energy Saving 10^{12} BTU	Oil Equivalent 10^6 BBL	Present Value Distortion Cost 10^6 1979 dollars	Present Value Revenue Loss 10^6 1979 dollars
Waste heat recovery	103.05	18.4	242.9	712.5
Non-oil combustors	9274.00**	1656.1**	12752.0	5014.0
Cogeneration	103.14	18.4	51.5	326.7
Solid waste recycling	0.161	0.029	0.39	1.13

Source: Brown and Anandalingam (Brown, S.P.A. and Anandalingam, G., 1981).

Note : * For all technologies 10% investment tax credits were extended over a period of 4 years.

** There is no net energy savings, only a substitution of coal for oil. So "energy savings" actually implies oil savings.

for all the technologies, it was found that the tax credits brought about increased energy-efficiency investments and savings in energy use. However the distortion costs and revenue losses were also quite large. In order for the energy savings to compensate for the public costs, the shadow price of oil would have to range from $ 81/bbkl for solid waste recycling to $ 40/bbl for cogeneration equipment. The former number is considered much too large by the U.S. Department of Energy. The latter number which involves a premium of $ 11/bbl (36 addition to the international price of oil) is just within the acceptable limits in the U.S. For a country that has a great demand for foreign exchange, an $ 11/bbl premium on the international price of oil would be well within acceptable norms. However, the generally accepted value of foreign exchange premium in India is 25%, or 7/bbl at the present international price of oil*. The analysis illustrated above needs to be

* private communication R.Bhatia, Institute for Economic Growth.

followed [illegible] the [illegible] of setting investment incentives [illegible] fully analysed.

Concluding Remarks

Actions which a private decision maker (i.e. a firm) will rationally take often differ substantially from actions which are best from a broad public perspective. This is particularly true in the case of investment for energy conservation in Indian industry. Disincentives, capital scarcity and other priorities for management all act to produce sub-optimal investment in energy efficient equipment. In addition, government pricing policies have distorted the energy market by keeping energy prices artifically low. This paper analysed government policies for providing incentives for industrial energy conservation in India and bringing private energy efficiency investment in line with national objectives.

Agressive development and implementation of energy efficiency technologies is the _sine qua non_ of any responsible energy plan. Another avenue for lowering the energy use per unit of production is the government to give incentives for _producers_ of energy efficient equipment, not just for those who install them. Such a programme will have much lower informational, contractual and policing costs mainly because there would be few companies that the government needs to interact with. Research and experience in the industralised countries has suggested that energy efficient technologies, in addition to saving energy, could play a vital role in improving industrial productivity. The improvement of industrial productivity is vital for the sustained growth of Indian industrial production. Government policy incentives for energy conservation must be carefully integrated with a comprehensive programme to increase industrial productivity and to meet important national objectives such as imported oil savings, improved balance of payments, increased employment and economic growth.

REFERENCES

1. ANANDALINGAM, G., (January 4-6, 1984) "The Economics of Industrial Energy Conservation in Developing Countries", in preparation. To be presented at the annual conference of the International Association of Energy Economists, New Delhi.

2. ANANDALINGAM, G., JHIRAD, D., MUBAYI, V. and WEINGART, J. "An Analysis of Incentives for Industrial Investments in Solar Energy in Developing Countries", submitted to Solar Energy.

3. ANON,. (1980) "Government sponsored Conservation Works in the U.K.", Energy, Business Communication Co., Stamford, CT., USA, Fall.

4. AHMEDABAD TEXTILE INDUSTRY'S RESEARCH ASSOCIATION, (May, 1982) Norms for the Textile Industry, part 4.

5. BOWONDER, B., (March, 1982) "Energy Management in Industries : Role of Government Agencies", ASCI Journal of Management.

6. BHATIA, R., (1983), "Planning for Petroleum and Fertilizer Industries", Oxford University Press, New Delhi.

7. BAUMOL, W.J. and WOLF, E.N. (1981) "Subsidies to New Energy Sources: Do They Add to Energy Stocks", Journal of Political, Vol. 89, No. 51.

8. BROWN, S.P.A. and ANANDALINGAM, G, (December, 1981) "Economic Analysis of Tax Credit Incentives for Business Investment in Energy Conservation and Production", BNL 51526, Brookhaven National Laboratory, New York.

9. CHRISTENSEN, L.R., JORGENSON, D.W. and LAU, L.J. (June, 1971) "Transcendental Logarithmic Utility

Function", American Economic Review, Vol. 65.

10. DEPARTMENT OF POWER, MINISTRY OF ENERGY, (1980) "Report of The Committee on Power", Government of India.

11. EISNER, R. and LAWLER, P.J. (March, 1975) "Tax Policy and Investment: An Analysis of Survey Responses", American Economic Review, Vol. 65.

12. M.W. GELLERSON, (September, 1978) "Marginal Cost-Based Electricity Tariffs : Theory and Case Study of India", Indian Economic Review.

13. HATSOPOULOS, G.N., GYFTOPOULOS, E.P., SANT, R.W. and WIDMOR, T.F., (March-April 1978) "Capital Investments to Save Energy", Harvard Business Review.

14. HENDERSON, J.N. and QUANDT, R.E. (1971) "Microeconomic Theory : A Mathematical Approach", McGraw Hill, 2nd edition.

15. LEE, J., MUBAYI, V. and ANANDALINGAM, G. January, 1983. "Energy Demand in non-OECD countries - Oil Demand, Informal Report, Brookhaven National Laboratory, New York.

16. RAVI SHANKAR, K., and PACHAURI, R.K. (1982) "A Study on Energy Use in India's Manufacturing Industries", unpublished mimeo, Administrative Staff College of India, Hyderabad.

17. SINGHANIA, V.K. and SINGHHANIA J. (1983) "Direct Taxes Ready Reckoner", Taxmann Publications, New Delhi.

18. THE ECONOMIC TIMES (August 17, 1983) "Big Increase in Coking Coal Prices Expected", New Delhi, pp 1.

19. URI, N.D.(1979) "Energy Demand and Inter-Fuel Substitution in India", European Economic Review, pp 181-190.